

PT Badak Natural Gas Liquefaction (NGL)

PT Badak Natural Gas Liquefaction (PT Badak NGL), founded in 1974, located in Bontang City, East Kalimantan, Indonesia which produces Liquefied Natural Gas (LNG) with a design LNG production capacity of 22.5 million tons/year. PT Badak NGL is a key player in the nation's energy sector, with all assets owned by the Indonesian government. Through installed capacity at 22.5 MTPA of LNG, the company serves both domestic and Asian export markets.

PT Badak NGL became the first oil and gas company in the world to successfully obtain the International Sustainability Rating System (ISRS) Series 8 Level 8 from the international agency DNV and was recommended as "A World LNG Plant Reference".



Figure 1 PT Badak NGL Plant Site – Bontang,

Case Study Snapshot	
Industry	Oil and Gas
Product/Service	LNG and LPG
Location	Bontang, East Kalimantan
Energy performance improvement percentage (over the improvement period)	13.3% improvement over 6 years
Total energy cost savings (over the improvement period)	USD 198,111,804.31 (over 6 years)
Cost to implement Energy Management System (EnMS)	USD 5,134,484 (over 6 years)
Total energy savings (over the improvement period)	8,460,721 MWh
Total CO₂-e emission reduction (over the improvement period)	1,741,796 Metric Tons

Organization Profile / Business Case

PT Badak NGL's journey towards advanced energy management is driven by a multifaceted motivation to enhance operational efficiency, reduce environmental footprint and align with global energy conservation trends. Remaining competitive in the international market have propelled the company to adopt robust energy-saving measures. Moreover, PT Badak NGL is motivated by a corporate responsibility to contribute to global environmental goals, aligning its initiatives with global frameworks such as the Sustainable Development Goals (SDGs) and the Kyoto Protocol. Since 2013, PT Badak NGL has been committed to sustainable energy practices, implementing a variety of initiatives. These initiatives include **generating green energy and reducing energy conservative consumption**.

Notable initiatives include the **installation of solar panels** on streetlights, office buildings, and across a sprawling 4-hectare land area. Furthermore, PT Badak NGL utilizes **wind power and utilizes wastewater flow** to further enhance its green energy production. Additionally, PT Badak NGL also produces **biodiesel from waste cooking oil** collected in employee residential. These efforts show PT Badak NGL's strong commitment to environmental responsibility and efficient resource use. By utilizing renewable energy sources and reducing waste, **PT Badak NGL is actively reducing its environmental impact and relying less on traditional energy sources**.

EnMS is integrally linked to PT Badak NGL's whole company strategy, acting as a crucial pillar for long-term sustainability and profitability. By implementing ISO 50001 standards, PT Badak NGL not only optimizes its energy use but also enhances overall operational resilience, allowing the company to handle energy sector problems with better agility and foresight. Our focus on energy conservation is evident through our EnMS, which has led to significant

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improvements in energy efficiency. **From 2018 to 2023, we reduced our energy consumption intensity from 6.95 GJ/ton LNG to 5.94 GJ/ton LNG.** Furthermore, our ISO 50001:2018 certification obtained in 2021 demonstrates our commitment to excellence in energy management, distinguishing us as **the first and the only LNG Plant in Indonesia with ISO 50001 certification.**

“As a part of energy performance improvement, specific management system is required to reorganize the energy management implementation to achieve the objective & target and sustainable improvement.”

—Achmad Khoiruddin, President Director (CEO)

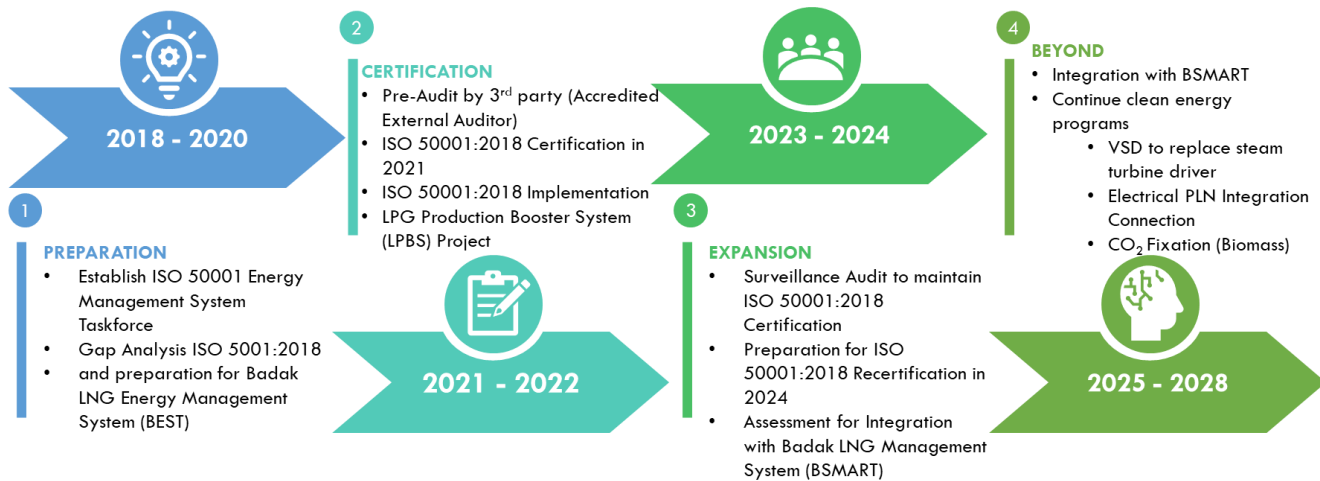


Figure 2 PT Badak NGL EnMS Roadmap

One of our biggest projects is **LPG Production Booster System (LPBS) Project**. This innovation was carried out by adding a condenser unit with Multi-Component Refrigerant (MCR) cooling media, the reflux rate was sufficient so that external butane was no longer needed, and our plant could produce more LPG products. It also reduces the use of steam / water while saving fuel gas usage in producing steam, so that feed gas from gas producers (raw material suppliers) can be maximized into LNG products. The budget for this innovation program is more than USD 4 million. The implementation of this program has an impact on energy consumption reduction of 2,614,234 GJ (726,176 MWh) and emission reduction of 3,876 tons of CO₂e. The cost saving resulting from this program is more than USD 17 million. With more LNG production and less energy consumption, in 2023 by implementing EnMS through this innovation we can get lower Energy Intensity.

PT Badak NGL also has net zero emission – decarbonization program which aligns with ISO 50010. The company's energy initiatives are directly linked to its commitment to the Sustainable Development Goals (SDGs) and Indonesia's national carbon reduction targets. PT Badak NGL contributes to a substantial reduction in CO₂ emissions, reinforcing its leadership role in promoting environmental sustainability in the energy sector. **In 2023, PT Badak NGL successfully reduced carbon emissions by 92,102 tons CO₂e** through the implementation of nine (9) decarbonization programs. At PT Badak NGL, we're proud to lead by example in embracing clean energy and sustainable practices, striving for a greener future.

PT Badak NGL's commitment to reducing conventional energy use and increasing the use of green energy is evidenced by its remarkable achievement of receiving the prestigious PROPER Gold award. **PT Badak NGL has received the PROPER Gold award for the thirteenth consecutive year since 2011.** The PROPER award is managed by the Ministry of Environment of the Republic of Indonesia and is granted to companies that show exemplary environmental management practices. The award evaluates companies on various environmental performance indicators, including

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pollution control, resource utilization efficiency, and community engagement. Earning this award demonstrates a company's ability to operate sustainably and responsibly, reinforcing PT Badak NGL's status as an environmentally conscious leader in the energy industry.

Business Benefits

At PT Badak NGL, implementing our Energy Management System (EnMS) has significantly advanced our sustainability and operational efficiency. This chapter will highlight how our strategic energy management approach has reduced costs and enhanced overall business performance. Through focused training and continuous improvement initiatives, we've deeply embedded energy efficiency into our corporate culture. We'll explore the specific benefits and outcomes of our EnMS, demonstrating our commitment to a sustainable and profitable future.

Capacity Building – To implement EnMS Top Management ensure our resource development. To make sure everyone is aware and understand about and capable to implement EnMS, there are several training and workshops that had been done, such as Manager Energy and Energy Auditor Training & Certification, Energy Management System Lead Auditor, Awareness of ISO 50006 & 50015/LCCA. PT Badak NGL Energy Management System (BEST) has also been disseminated through all employees. A total of **USD 41,934** was invested in at least 131 of the employees during the reporting period.

Conserving Energy – From 2018 to 2023, the data shows a significant reduction in total energy consumption, dropping from 58.67 million GJ to 26.12 million GJ, a decrease of approximately 32 million GJ (9.0 million MWh). Although there are other factors, It is mostly the result of implementing EnMS (energy saving around 8.46 million MWh). By comparing annual energy saving to annual expected energy consumption, nearly 13.3% EnPI improvement in energy efficiency illustrates our proactive efforts to improve and enhance our production processes, demonstrating our commitment to sustainable energy use.

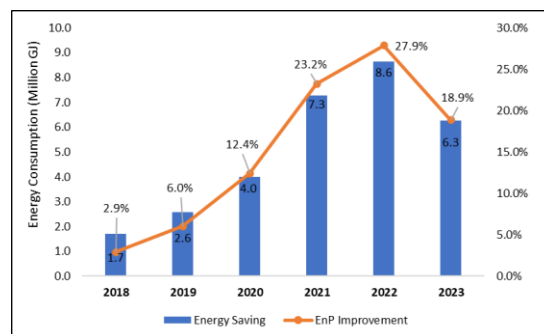


Figure 3 Energy Performance Improvement

Energy Cost Saving – From 2018 to 2023, our energy management strategies have led to a dramatic decrease in energy costs of fuel gas from \$334 million to \$176 million with basis natural gas prices at USD 6/MMBtu. By setting the 2018 figures as baseline, PT Badak NGL have been able to track and quantify the direct impact of our initiatives, which demonstrates energy cost saving.

The red line graph shows cumulative cost savings increasing to over \$57.9 million by 2023, indicating the aggregate financial benefit of energy-saving strategies. This combination of declining annual energy costs and growing cumulative cost savings highlights our commitment to sustainable energy practices, resulting in a more resilient and efficient operation.

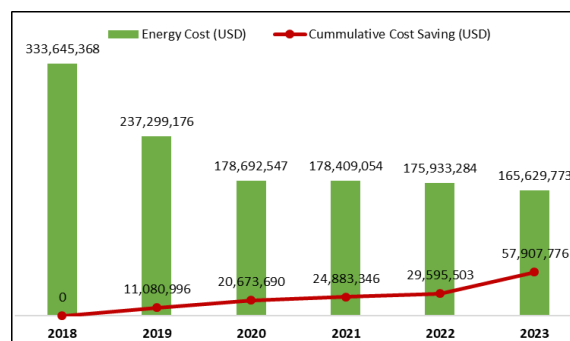


Figure 4 Emission Reduction and Intensity 2018-2023

GHG Emission Reduction – Along with Indonesia's regulation to reduce the emission by 29% in 2030, PT Badak NGL supports the Government's effort to reduce CO₂ emissions as well as develops energy transition in LNG Industries. PT Badak NGL emission intensity metrics have also reflected this commitment, holding at 0.48 ton CO₂e/ton in 2018 and then improving significantly after our strategic enhancements. By 2023, we managed to reduce the intensity to an impressive 0.37 ton CO₂e/ton. The CO₂ emission intensity decreased by approximately 22.92% from 2018 to 2023 and this commitment will continue.

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Renewable Energy – In addition to programs aimed at saving fossil fuel resources, PT Badak NGL has also been developing alternative energy applications through its "Green Electricity" program. This initiative began in 2013 with the installation of solar power generation facilities on office buildings. It progressed in 2015 with the installation of solar panels coupled with LED street lighting. The program expanded in 2017 to include the installation of a Hybrid Wind-Solar Power System (PLTBS). In 2018, PT Badak NGL significantly expanded its renewable energy initiatives. The company installed a large-scale solar power plant covering 4 hectares area and established a mini biodiesel plant to transform used cooking oil from employee housing into fuel for its vehicle fleet.

PT Badak NGL is pioneering a greener future by tapping into renewable energy sources. This proactive approach has led to the establishment of a robust renewable energy infrastructure with an installed capacity of 4,007 kWp, catalyzing energy conservation with savings of 6,176 GJ/year and a commendable reduction in carbon emissions by 1,245 tons of CO₂e. These initiatives are a testament to PT Badak NGL's dedication to environmental sustainability, providing internal benefits and contributing positively to the health of our planet and local communities.

Table 1 Renewable Energy Contribution to Energy Consumption

No.	Program	Capacity	Contribution to Energy Consumption	Description
1	Solar Cell Farm	4 MWh	10%	Connect to plant electrical grid
	Solar Cell	400 kWh	1%	Solar cell to aid: - Main Office Building Power Supply - Marine Equipment and Streetlight
2	Wind power plant	7 kwp	0.018%	Connect to plant electrical grid
3	Micro-hydro Generator	0.25 kwp	0.0001%	Electricity for local community
4	Biodiesel	40 L/week	0.33%	For operational vehicle and donated to local fisherman

Corporate Social & Governance Benefits - The implementation of EnMS benefits is not only for the company but also the stakeholders such as the community on a socioeconomic level. This matter can be seen in PT Badak NGL's EnMS implementation's contribution to the Sustainable Development Goals (SDG) targets, namely.

- Goal 7 (Affordable and Clean Energy) in the form of implementing renewable energy such as solar, wind and water.
- Goal 13 (Climate Action) in the form of reducing greenhouse gas emissions.
- Goal 12 (Responsible Consumption and Production) in the form of reducing waste cooking oil by processing and producing into biodiesel which then used as fuel for company vehicle.

Other benefits of improving the company's image provide:

- Achieving Gold-Rating (Beyond Compliance) in the National Program for Assessment Performance Rating in Environmental Management (PROPER) from the Ministry of Environment and Forestry (2011-2023). The PROPER Gold Award is the highest honor for companies excelling in green practices, like implementing energy efficiency, reducing emissions, saving water, reducing pollution, managing waste wisely and protecting biodiversity.
- Winner of National Energy Efficiency Award (Subroto Award for Energy Efficiency) 2023.
- Global CSR & ESG Summit 2024
- Eight (8) patents in the field of energy efficiency by Directorate General of Intellectual Property (Direktorat Jenderal Kekayaan Intelektual – DJKI).

Multiple Sites Benefits

PT Badak NGL Business Structure is an Integrated LNG Seller which means LNG sales are conducted by both Gas Producers and LNG Plant Operator, in this case is PT Badak NGL. By implementing EnMS, it helps us to increase Plant Thermal Efficiency up to 89%. It means 89% of Natural Gas is converted to LNG products while the rest is used as fuel gas. It is also described in our EnPI – Fuel Gas Percentage. Gas Producers as Upstream business process will get the

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benefit of an effective production cost due to energy cost saving. PT Badak NGL is also can be more competitive for downstream business process, LNG Transporter and Buyers. In this dynamic LNG market, having LNG Products produced from an efficient LNG will make us more preferable due to reliable LNG Plant. This reliability is obtained by implementing EnMS.



Figure 5 LNG Business Chain – Integrated System

Plan

PT Badak NGL Top Management was aware that PT Badak NGL needed to implement an Energy Management System immediately. There are several steps that need to be organized such as Management System, Leadership, Energy Planning, Competence of our resources, and Monitoring before implementation.

Leadership

1. In PT Badak NGL Energy Policy, it states the target of Energy Saving in 3 years. In this example for Energy Policy issued in 2022, the target is 10.5 million GJ in 3 years. This policy is signed by the Director & COO.
2. Establish energy management task force officially issued on Decree of Director & COO.

Budget Commitment – Top Management ensure capacity building such as energy manager, energy auditor dll training and certification manged by Training Section under Human Capital Departemnet. Selain itu, baru program CIP dll (innovation in PT Badak NGL berjalan) under both SHE&Q Department and Technical Department.

Energy Management System:

1. Develop energy management procedures called PT Badak NGL Energy Management System (BEST). It consists of 1 (one) Manual and 10 Standard Operational Procedures (SOP).
2. Determine context of organization by
 - a. identifying internal & external issues, and
 - b. mapping stakeholders need & expectation.
3. Define EnMS scope. The boundary Process Trains Area, Utilities Area, Storage Loading & Marine Area, Associated facility at Bontang LNG Plant Site. The scope of PT Badak NGL Energy Management System (BEST) covers Refrigerant Compressors, Boilers, and Amine Regenerators.

Energy Planning

PT Badak NGL has conducted an energy review by analyzing energy use and consumption, then we Identify SEU based on the analysis. PT Badak NGL consumes natural gas as its main energy source. The energy source is dominantly utilized for converting boiler feed water into high pressure steam in boiler. High-pressure steam produced is used for heating mediums, turbine driver and electricity generation.

“By implementing PT Badak NGL Energy Management System (BEST), we could organize what we have done and achieve target of Energy Performance more effectively.”

—M. Arief Setiawan, Process Engineering & Energy Conservation Manager

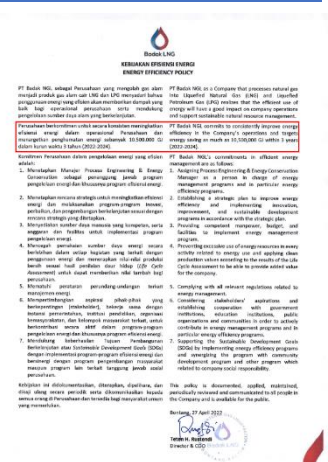


Figure 6 Energy Policy



Figure 7 PT Badak NGL Energy Management System Manual and SOPs

Do, Check, and Act

EnPI – From Energy Review we identify Significant Energy Use (SEU) are Boilers and Refrigerant Compressors as the highest energy consumer or the equipment with the highest potential energy saving. This Sankey Diagram shows Energy Performance Indicators (EnPI) by level.

PT Badak NGL has determines four EnPI, those are:

- **Level 1: Fuel Gas Percentage compared to Feed Gas.**
- **Level 2: Fuel to Steam Ratio.**
- **Level 3: Steam to LNG ratio (whole plant).**
- **Level 4: Steam to LNG ratio of Refrigerant Compressors.**

Indicator to Monitor EnPI

- LNG Flow Rate (5FI-6)
- Steam Consumption
- Fuel Gas Consumption
- Feed Gas Flow Rate

We create energy base line based on measurement and other data i.e.: identifies the regression of steam produced compared to LNG Production rate. This regression is used to make Energy Baseline and define the Energy Target. Method of Steam to LNG ratio ratio whether for whole system or specifically for refrigerant compressor is determined as follow:

$$\text{Steam to LNG} = \frac{\text{Steam Production (ton)}}{\text{LNG Production (m3)}}$$

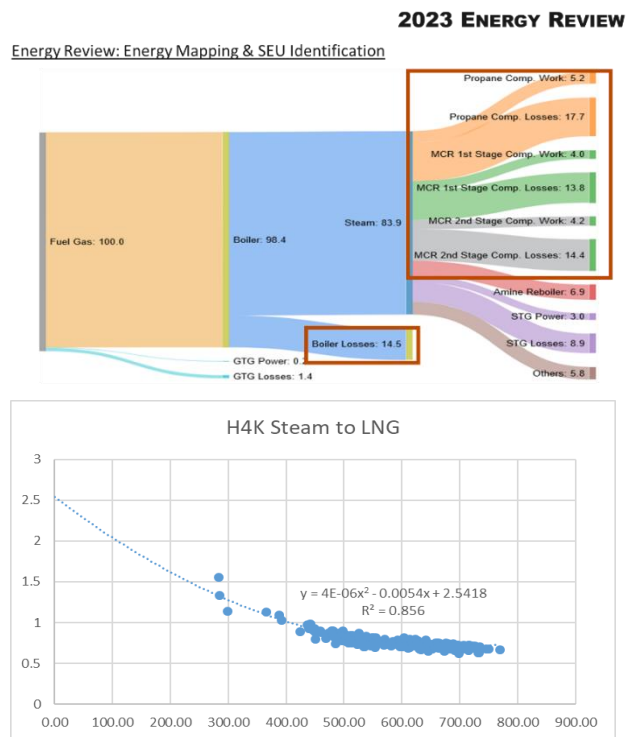


Figure 8 Energy Review to determine EnPI and Energy Baseline

Fuel gas percentage and Fuel to Steam ratio determination compared to feed gas is as follow:

$$\% \text{ fuel gas} = \frac{\text{Fuel Gas Consumption} \left(\frac{\text{kNm}^3}{\text{h}} \right)}{\text{Feed Gas Flowrate} \left(\frac{\text{kNm}^3}{\text{h}} \right)} \times 100\%$$

$$\text{Fuel to Steam} = \frac{\text{Fuel Cons.} \left(\frac{\text{kNm}^3}{\text{h}} \right)}{\text{Steam Prod. (ton)}} \times 100\%$$

After Energy Performance and Baseline is proposed by Energy Manager based on review and scope and Energy Target and Objective is determined then Energy Program is selected. Energy program is recommended by energy auditor. Choosing priority for Energy Program is conducted by assessment using priority scale matrix. A general matrix is developed for performing the semi-quantitative priority selection of Energy Program. The priority scale is based on program type and potential saving, or investment cost & potential energy efficiency created.

CIP – Patent. Continuous Innovation Program (CIP) is the pillar of PT Badak NGL Energy efficiency program. A lot of CIP Group had been in National and even International Competition and got awarded. With a sustained commitment to implementing ISO 50001, PT Badak NGL consistently generates new innovations each year, resulting in eight patents in the field of energy efficiency. These advancements not only enhance our energy management practices but also significantly contribute to the future intellectual property portfolio of PT Badak NGL, strengthening our competitive position in the LNG industry.

We validate and verify the performance has improved by conducting monitoring, measurement, and evaluation of determined energy performance through dashboard **weekly** on Plant Coordination Meeting (PCM) every Tuesday morning.

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What needs to be monitored and measured, including at a minimum the following key characteristics:

- Baseline vs Target vs Actual of EnPI(s) and the operation of SEUs
- Analysis and Evaluation, as applicable, to ensure valid result and follow up plan.

Furthermore, we also conduct **EnMS internal audit** and **Management Review** to prepare for 3rd party external audit. Management Review was done at least twice a year.

Variables that Impact Energy Consumption – There are lot of Feed Gas Flow Rate, Feed Gas Composition, Running Train Mode, or Load Factor, lower than its maximum capacity, Process Technology (Steam Turbine less than efficiency 80%) compared to newer LNG Plant which use Motor Driver which has efficiency up to 95%.

Specific Energy Consumption – or also known as Energy Intensity. since LNG production affects energy consumption, normalization is needed by comparing the intensity. To ensure normalized energy consumption in an LNG plant, energy consumption (measured in gigajoules, GJ) is divided by the total LNG production (measured in tons). This method, called "specific energy consumption" (SEC), helps in standardizing and comparing energy efficiency across different plants or over time within the same plant. Here's how to implement this method:

1. Measure Total Energy Consumption: Record the total energy consumed by the plant over a specific period. This includes energy used in all processes such as gas treatment, liquefaction, refrigeration, and utilities.
2. Measure Total LNG Production: Record the total amount of LNG produced during the same period. This is typically measured in tons.

$$\text{Specific Energy Consumption} \left(\frac{\text{GJ}}{\text{ton LNG}} \right) = \frac{\text{Total Energy Consumption (GJ)}}{\text{Total LNG Production (ton LNG)}}$$

By calculating and analyzing SEC, LNG plants can ensure normalized energy consumption, identify inefficiencies, and implement strategies to improve overall energy efficiency.

Operational Control and Design. PT Badak NGL has considered energy performance improvement opportunities and operational control in the design of new, modified, and renovated facilities, equipment, systems, and energy-using processes that can have a significant impact on its energy performance over the planned or expected operating lifetime. The results of the energy performance consideration shall be incorporated into specification, design, and procurement activities. Documented information of the design activities related to energy performance shall be retained. The design procedure can be seen in the Project Management SOP. A guidance of design related energy is stated in General Specification (GenSpec) documents.

Procurement. PT Badak NGL has established and implemented criteria when procuring energy using products, for example when purchasing electronic equipment make sure it has 4-star rating (refer to Indonesian Ministry of Energy and Mineral Resources Decree)

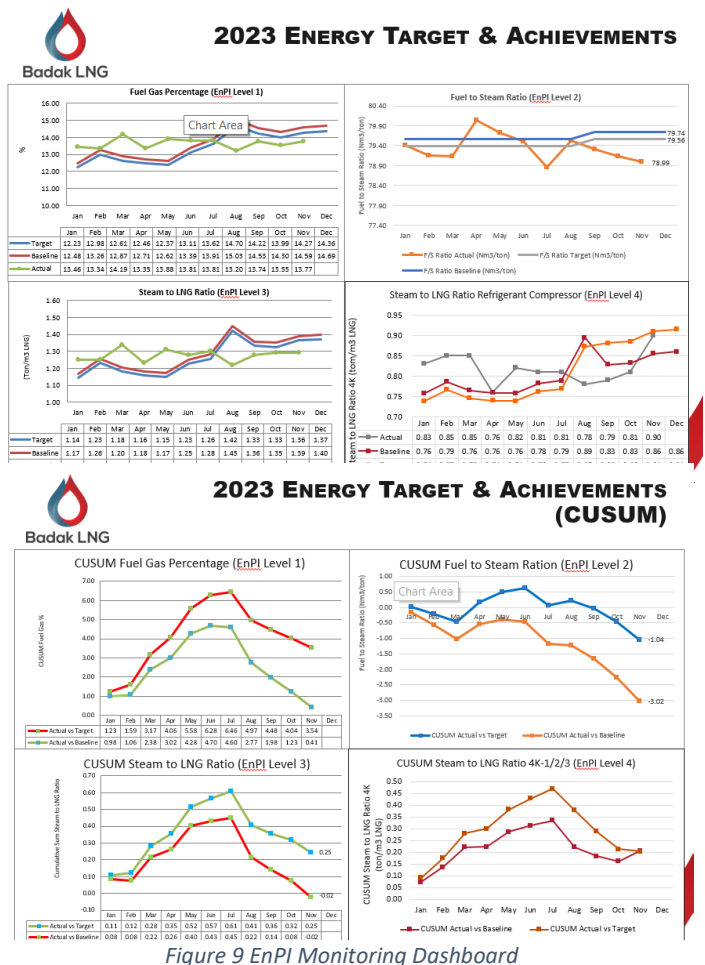


Figure 9 EnPI Monitoring Dashboard

Transparency

- Online Energy Management Reporting (POME) by Indonesian Ministry of Energy and Mineral Resources (<https://simebtke.esdm.go.id/sinergi/>)
- ISO 50001:2018 certification on Sustainability Report (page 19) (<https://badaklng.com/id/media/attachments/2023/10/11/sustainability-report-badak-lng-2022.pdf>)
- PROPER Gold the 13th consecutive year since 2011 (<https://www.cnbcindonesia.com/news/20231222103527-4-499496/mantap-badak-lng-sabet-proper-emas-yang-ke-13-kalinya>)
- Subroto Awards 2023 (https://badaklng.com/index.php?option=com_content&view=article&id=374:penghargaan-subroto&catid=80&Itemid=437)
- Mass Media Publication about PT Badak NGL awarded Subroto Awards for its Energy Management System ISO 50001 Implementation (<https://www.dunia-energi.com/badak-lng-sabet-penghargaan-subroto-2023-kategori-manajemen-energi-di-bangunan-gedung-dan-industri/>)
- Mass Media Publication about PT Badak NGL Energy Efficiency Program and Energy Management System ISO 50001 (<https://www.antaraneews.com/berita/3741210/badak-lng-berkolaborasi-dengan-pln-terapkan-inovasi-efisiensi-energi>)
- Global CSR & ESG Summit 2024 (https://badaklng.com/index.php?option=com_content&view=article&id=388:global-csr-esg-summit-2024&catid=80&Itemid=437)

What We Can Do Differently

Lesson Learned – PT Badak NGL had been conducting External Energy Assessment since 2009, driven by the need to improve plant thermal efficiency. However, based on Gap Analysis conducted in 2019, previous energy management implementation is not systematic according to PDCA cycle. Therefore, we started to conduct an Energy Review, set our Energy Target and Objectives based on selected EnPI to give a more systematic approach to define what program should be implemented for Energy Efficiency Program. Integrating EnMS in our procedure makes us work more efficiently.

Another lesson learned, we state in our SOP (**BEST/SOP 06-Operational Control of Energy, Clause 11 Procurement**, recommendation improvement is given to include the following subject as additional technical qualification or standard competency, e.g. Life Cycle Costing Analysis (LCCA) for Procurement Team.

Way Forward – PT Badak NGL will keep going implementing clean energy program starting by doing feasibility study to substitute old technology by greener choice such as VSD to replace steam turbine, and CO₂ fixation by using algae to capture CO₂ release from Acid Gas Removal Unit Regeneration Unit as one of the biggest CO₂ emissions sources. Last but not least, would like to integrate EnMS to PT Badak NGL Management Systems & Attitude Reinforcement Technique (BSMART). If we redo our EnMS, we would like to change how the Organization identifies and evaluates applicable legal and other requirements related to energy efficiency, energy used and energy consumption at PT Badak NGL register. It may be beneficial to review and identify as necessary into register, for example there is a Regulation of the Minister of Environment and Forestry No 21/2022 about “Procedure for Implementing the Economic Value of Carbon”.



Figure 10 BEST SOP 06 - Operational Control of Energy



The Energy Management Leadership Awards is an international competition that recognizes leading organizations for sharing high-quality, replicable descriptions of their ISO 50001 implementation and certification experiences. The Clean Energy Ministerial (CEM) began offering these Awards in 2016. For more information, please visit www.cleanenergyministerial.org/EMAwards.